



PROGRAM
entrance test in chemistry

I. Scope of application and regulatory references

The admissions test program was developed for those entering the SPSPMU of the Ministry of Health of Russia for training in higher education programs: bachelor's programs and specialist programs based on the requirements of the Federal State Educational Standard of Secondary (Complete) General Education (Order of the Ministry of Education and Science of Russia dated May 17, 2012 No. 413).

II. The program of the entrance test in chemistry

Ia General chemistry

1. Atom. The structure of the atom.

The concept of an atom, molecules, ions, valence, energy levels, oxidation state, electron spin, possible valences, possible oxidation states. The concept of unpaired electrons, electron pair.

2. Periodic table of chemical elements D.I. Mendeleev.

Periodic table, arrangement of elements, periods, groups, their meaning. Metals, non-metals. Metallic properties.

Determination of belonging of elements to s-, p-, d-series. Electronic configuration of elements. Pauli's principle, Hund's rule.

Electronegativity. Electronegativity scale.

Change in metallic properties, atomic radius, electronegativity by period and group.

3. The main classes of inorganic compounds:

oxides, acids, hydroxides, salts.

Oxides. Determination of oxides. Classification. The concept of salt-forming, non-salt-forming oxides. Basic, acidic, amphoteric oxides. Definitions. Chemical properties of basic, acidic, amphoteric oxides.

Acids. Nomenclature. Classification of acids. One-, two-, polybasic acids. Oxygen-containing and anoxic acids. Acids as electrolytes: strong, weak. Chemical properties. Interaction of metals with concentrated and dilute acids, depending on the activity of the metals. A number of metal activities. Methods for obtaining acids.

Hydroxides. Nomenclature. Classification of hydroxides. One-, two-, multi-acid hydroxides. Alkalis. Amphoteric hydroxides. Hydroxides as electrolytes. Chemical properties of hydroxides. Decomposition of insoluble metal hydroxides. Ammonium hydroxide. Getting hydroxides.

Salts. Nomenclature. Classification: acidic, medium, basic, complex salts. Soluble and insoluble salts. Chemical properties of salts. Decomposition: carbonates, nitrates, acidic and basic salts. Methods for obtaining salts.

Hydrolysis. Hydrolysis concept. Acidity of the medium, pH (pH). Acidic, neutral, alkaline environment. pH value. Indicators as indicators of the acidity of the environment. Hydrolysis by cation, anions, by both ions.

Electrolysis. Electrolysis concept. Anode and cathode charges during electrolysis. Peculiarities of electrolysis of salts with oxygen-containing acid residue, anoxic acid residue. Features of electrolysis of salts of active metals, metals of medium activity and inactive metals.

4. Chemical bond

Covalent bond. Electronegativity. Polar, non-polar communication. The mechanism of covalent bond formation.

The concept of a common electronic pair. Donor and acceptor of an electron pair. Colligative, donor-acceptor mechanisms of covalent bond formation.

The concept of a radical. Mechanisms for breaking a covalent bond. Homolytic (radical) and heterolytic (ionic) mechanisms of breaking a covalent bond.

Covalent bond parameters.

Bond length (length of C-C single bond, C = C double bond, C \equiv C triple bond), bond angle, hybridization of atomic orbitals. L. Pauling's theory of hybridization. Types of hybridization on the example of atomic orbitals of carbon: sp³, sp², sp - hybridization.

Directivity, polarity of communication.

Metallic bond. Definition. Metal crystal lattice.

Ionic bond. Ionic crystal bond.

Hydrogen bond. Educational conditions. Intra- and intermolecular hydrogen bond.

Crystal lattice: atomic, molecular, ionic, metallic.

5. Redox reactions.

The concept of an oxidizing agent, a reducing agent. Intra- and intermolecular redox reactions. Electronic balance. Oxidation, reduction processes.

6. Chemical kinetics. The concept of forward and backward reactions.

a. The rate of chemical reactions. Factors affecting the change in the rate of a chemical reaction. Influence of the concentration of starting materials on the rate of direct reaction. Van't Hoff's rule, the effect of temperature change on the rate of a chemical reaction. Van't Hoff coefficient. Influence of pressure on the rate of direct reaction. Catalysts, reaction inhibitors. Enzymes as biocatalysts.

b. Chemical equilibrium. Factors affecting the shift in chemical equilibrium. Changes in the concentration of starting materials and reaction products. The concept of endothermic and exothermic reactions. The effect of increasing and decreasing temperature during exo- and endothermic reactions. Pressure as a factor affecting the displacement of equilibrium in the presence of gaseous substances.

Iib. Inorganic chemistry.

1. Subgroup of halogens.

Halogens as elements. Change in metallic properties, atomic radius, electronegativity for the halogen group. The structure of halogen atoms. Possible oxidation states, halogen valences. The specificity of fluorine as the most electronegative atom.

Chemical properties of halogens. Interaction with simple and complex substances. Reactions of halogens with alkalis when heated and cold. Redox reactions of halogens. Disproportionation reactions. Obtaining halogenated compounds.

Hydrohalic acids. Change in acidity in the series of hydrohalic acids depending on the electronegativity of the halogen. Hydrofluoric acid as a weak electrolyte.

2. Oxygen subgroup.

The structure of oxygen, sulfur, selenium, tellurium atoms. Possible oxidation states, valences. Changes in metallic properties, atomic radius, electronegativity for the chalcogen group.

Allotropy. Allotropic modifications of oxygen, sulfur. Ozone. Ozone formation reaction. Oxidizing capacity of ozone.

Chemical properties of oxygen, sulfur. Reactions with simple and complex substances. Methods for producing oxygen. Water is a weak electrolyte. Intermolecular hydrogen bonds. Abnormally high boiling point of water.

Sulfur acids. Hydrogen sulfide, sulfurous, sulfuric acids. Chemical properties. Interaction with metals of different activity. Diluted and concentrated sulfuric acid, peculiarities of interaction with metals. The hygroscopic properties of sulfuric acid. Sulfuric and sulfurous acid salts. An industrial method for producing sulfuric acid. Oleum.

3. Nitrogen subgroup

The structure of nitrogen and phosphorus atoms. Allotropic modifications of phosphorus. Change in metallic properties, atomic radius, electronegativity for the nitrogen subgroup. Oxidation states, valences of elements of the nitrogen subgroup.

Chemical properties of nitrogen, phosphorus. Nitrogen oxides. The nature of nitrogen oxides. Chemical properties of nitrogen oxides. Nitrous, nitric acid. Chemical properties of nitric acid. Interaction of concentrated and dilute acids with metals. Getting nitric acid.

Ammonia. Ammonia. Nitrates. Decomposition of metal nitrates. Nitrogen fertilizers. Saltpeter.

Phosphoric acid. Stepwise dissociation of phosphoric acid. Chemical properties of phosphoric acid.

Salts of nitric, nitrous and phosphoric acids. Phosphate fertilizers.

4. Subgroup of carbon:

The structure of carbon atoms, silicon. Allotropic modifications of carbon. Carbon oxides. Synthesis gas. Redox reactions with carbon monoxide (II). Chemical properties of carbon monoxide (IV). Carbonic acid. Stepwise dissociation of carbonic acid. Chemical properties. Carbonic acid salts.

Baking and technical soda. Glass.

5. Boron subgroup.

The structure of boron and aluminum atoms. Change in metallic properties, atomic radius, electronegativity in the third group of the main boron subgroup.

Aluminum oxide as an amphoteric oxide. Interaction with alkalis in aqueous solutions, during fusion. Silica. Aluminum hydroxide, amphotericity of hydroxide.

6. Elements 1 and 2 of groups of main subgroups

Alkali and alkaline earth metals. Features of the structure. Change of metal properties by group. Hydroxides of alkaline and alkaline earth elements.

7. d - elements.

Features of the structure of atoms of d - elements. Chromium, iron, manganese. Structure. Chemical properties of iron oxide (II), iron oxide (III), chromium (II) oxide, chromium (III) oxide. Chromic, dichromic acids. Chromates, dichromates. Manganese oxides (II), (IV), (VII). Manganic and permanganous acids. Potassium permanganate. Change in the oxidation state of manganese in the permanganate anion depending on the medium: acidic, neutral, alkaline.

IIIc . Organic chemistry.

1. Theory of the structure of organic compounds A.M. Butlerov.

Basic concepts of organic chemistry.

L. Pauling's theory of hybridization. The concept of σ - and π -bond. Isomerism. Isomers. Types of isomerism. Structural, geometric, optical isomerism, isomerism of the position of a multiple bond, the position of a functional group, interclass isomerism.

Classification of organic compounds. Functional groups. Particles in organic chemistry. Radical, electrophile, nucleophile. Types of chemical reactions in organic chemistry. Addition, substitution, elimination reactions. Reaction mechanisms. Formation of σ - and π -complex. IUPAC nomenclature of organic compounds.

2. Alkanes

Alkane nomenclature, alkane structure, single bond. Alkyl radicals. Combustion reactions, radical substitution. Halogenation and nitration conditions. Konovalov's reaction. Cracking of alkanes. Dehydrogenation. Dehydrogenation catalysts. Oxidation of alkanes. Getting alkanes. Wurtz reaction, decarboxylation of carboxylic acid salts by fusion with alkalis, by electrolysis of aqueous solutions of these salts. Hydrogenation of haloalkanes. Carbide method for producing methane. Distillation of oil.

3. Alkenes.

Alkenes nomenclature. Alkenes structure. Double bond. Geometric, cis-trans-isomerism of alkenes. Interclass isomerism with cycloalkanes.

Double bond addition reactions. Markovnikov's rule. Hydration, hydrohalogenation of alkenes. Kharash's peroxide effect.

Halogenation reactions (with bromine water). Interaction with aqueous and acidic solutions of potassium permanganate, ozone.

Polymerization of alkenes. Polyethylene. Polypropylene.

Alkenes production. Dehydrogenation of alkanes. Intramolecular dehydration of alcohols. Dehydrohalogenation of haloalkanes in an alcoholic medium. Zaitsev's rule.

3. Alkyne

Alkyne nomenclature. Triple bond. The structure of alkynes. Chemical properties of alkynes. Hydration of alkynes - Kucherov's reaction. Halogenation, hydrohalogenation, hydrogenation, alkynes oxidation. Di- and trimerization of alkynes. Divinyl. Trimerization of acetylene, propyne. Acidic properties of terminal triple bond alkynes. Reaction with sodium. Methods for obtaining alkynes. Double dehydrohalogenation of dihaloalkanes. Carbide method for producing acetylene.

4. Alkadienes.

Nomenclature of alkadienes. The structure of alkadienes. Addition reactions 1,2 and 1,4. Hydrogenation, halogenation, hydrohalogenation, hydration of alkadienes. Oxidation with potassium permanganate solution in sulfuric acid solution and aqueous solution ; ozonolysis. Polymerization of alkadienes. Synthetic rubbers. Vulcanization of rubbers. Rubber.

5. Cycloalkanes.

Cycloalkane nomenclature. The structure of cycloalkanes. Ring opening reactions. Dehydrogenation of cycloalkanes. Receiving.

7. Alcohols

Nomenclature of alcohols. The structure of alcohols, hydroxy groups. Classification of alcohols. One-, two- (glycols), polyhydric alcohols. Intermolecular hydrogen bonds. Chemical properties of alcohols. Acidic properties. Glycols. Glycerol. Glycerin nitration. Qualitative reaction with copper (II) hydroxide .

8. Carbonyl compounds. Aldehydes, ketones.

Nomenclature of carbonyl compounds. The structure of the carbonyl group. Addition reactions at the carbonyl group. Redox reactions of aldehydes. Cannizzaro's reaction. The qualitative reaction to the aldehyde group is the silver mirror reaction. Obtaining aldehydes and ketones. Hydration reactions of alkynes, oxidation of alkenes, alkynes, alcohols.

9. Carboxylic acids.

Nomenclature of carboxylic acids. The structure of the carboxyl group. The presence of intermolecular hydrogen bonds. Acidic properties. Reactions with metals, metal hydroxides, ammonia. Halogenation at the alkyl group, at the carboxyl function. Esterification reaction. Esters. Hydrolysis of esters (alkaline, acidic).

Unsaturated carboxylic acids. Acrylic acid. Features of hydrohalogenation of acrylic acid. Methods for obtaining carboxylic acids.

10. Benzene and its homologues.

a. Benzene structure. Hückel's rule. Aromaticity. Chemical reactions of hydrogenation and halogenation in the light. Substitution reactions at the benzene ring.

Getting benzene. Trimerization of acetylene. Decarboxylation of metal benzoate.

b. Toluene (methylbenzene)

Toluene structure. Orientation in the benzene ring. *Ortho* -, *pair* -, *meta*- orientation. Methyl radical reactions. Halogenation in the light. Oxidation of toluene and benzene homolog to benzoic acid. Oxidation of isopropylbenzene (cumene) to phenol. Reactions at the expense of the benzene ring. Alkylation, halogenation, nitration in the presence of catalysts. Getting *ortho* - and *steam* - products.

11. Phenol. Aromatic alcohols.

The structure of phenol. The acidity of the hydroxy group. Reactions on the benzene ring. Halogenation, nitration, phenol alkylation. Getting *ortho* -, *steam* - products. Bromination of phenol with bromine water. Polycondensation with formaldehyde. Obtaining phenol-formaldehyde resins. Getting phenol. Picric acid.

12. Benzaldehyde.

Benzaldehyde structure. Redox reactions. Cannizzaro's reaction. Reactions of halogenation, nitration, alkylation in the presence of catalysts. Getting a *meta*- product. The reaction of the silver mirror. Getting benzaldehyde.

13. Benzoic acid.

The structure of benzoic acid. Reactions at the carboxyl group, benzene ring. Halogenation with carbon pentachloride, halogen in the presence of a catalyst. Nitration, alkylation on the benzene ring in the presence of a catalyst. Getting a *meta*- product. Methods for producing benzoic acid. Benzoates.

14. Amines.

Classification of amines. Primary, secondary, tertiary amines. Nomenclature of amines. Basicity of amines. Chemical properties of amines. Alkylation, oxidation of amines. Interaction with inorganic acids. Qualitative reaction to primary amines. Getting amines.

15. Aniline

Aniline structure. Chemical properties of amines due to the amino group, due to the benzene ring. Gelogenation with bromine water. Halogenation, alkylation, nitration of aniline in the presence of a catalyst. Getting aniline. Zinin's reaction.

16. Amino acids.

The structure of amino acids. Amphoterocity of amino acids. Isoelectric point. Bipolar (zwitter) ion. Classification of amino acids. Essential amino acids. Chemical properties due to amino and carboxyl groups.

17. Carbohydrates.

Classification of carbohydrates. Mono, di-, polysaccharides. Glucose is an aldehyde alcohol. Fructose is a ketoalcohol. The reaction of the silver mirror to glucose. Disaccharides. Sucrose, maltose. Polysaccharide. Starch. Cellulose.

18. Lipids.

Lipid classification. Saturated and unsaturated fats. Animal and vegetable fats. Hydrolysis, saponification of fats.

IV. The form of the entrance test

The exam is in interview format.

1. The structure of the entrance test

The entrance test consists of questions in accordance with the above program of the entrance exam.

2. Indicators and criteria of the result of the entrance test, grading scale and procedure

When completing the tasks of the entrance test in chemistry, the applicant must show knowledge in writing electronic configurations of various elements, determine the possibility of

the formation and existence of various types of chemical bonds between atoms, molecules, be able to apply knowledge about the properties of the general class of compounds on specific molecules, based on knowledge about general changes in the periodic table to be able to predict the expected properties of substances, atoms, to make the necessary calculations.

When performing assignment requires knowledge of common patterns in a number of classes, the group of compounds forming a single presentation and logic in the development of chemical properties inherent x certain groups of compounds.

The ionic ticket exam includes 5 questions.

20 points for tasks # 1 and # 2, the final score is reduced by 5 in case of an incorrect answer;

10 points for task number 3, the final score is reduced by 2 points in case of an incorrect answer;

25 points for assignments №№ 4,5, the final score is reduced by 5 in case of an incorrect answer.

Thus, in general, an applicant who has correctly completed tasks 1–36 of the entrance test receives 100 points. The result of the entrance test is considered positive if the sum of the points scored corresponds to the minimum number of points established by the Rules for admission to study in higher education programs - bachelor's programs, specialty programs in 2025 at the FSBEI HE SPbSPMU MOH Russia in the relevant field of study (specialty), or exceeds it.

Sample exam ticket

Describe the structural configuration of the element ..., the possible oxidation states and electronic configurations in these oxidation states; what chemical bonds a given atom can form; provide examples with explanations.

1. Describe the hydrolysis process for the following salt... (write in ionic form, including all the necessary steps, give the names of the intermediate ions formed); determine the acidity of the environment.

2. Make the next transition....

3. Solve the problem: during the decomposition of nitrate (carbonate ...) ... g of solid residue was formed, ... l of solution ... with concentration ... and density ... as a result of the reaction released ... l of gas.

Calculate the mass of the starting nitrate ... and the volume of the gas mixture evolved during decomposition.

5. During combustion ... g of organic matter released ... l of carbon dioxide and ... g of water. Determine the gross formula of an organic substance if it is known that it contains a tertiary carbon atom and reacts with an ammoniacal solution of silver oxide.

Recommended reading:

1. Gabrielyan O.S. Chemistry. Grade 11. Basic level: textbook. for general education. at lesions. M. Drofa, 2008.223 p.
2. Khomchenko G.P. Chemistry for university applicants. M.: Novaya Volna, 2002.480s.
3. Doronkin V.N., Berezhnaya A.G., Sazhneva T.V., Fevrалеva V.A. Unified State Exam. Chemistry. A great reference book for preparing for the exam. Legion. 2019.560 p.
4. Doronkin V.N., Berezhnaya A.G., Sazhneva T.V., Fevrалеva V.A. Unified State Exam Chemistry. 10-11 Classes. Tasks of a high level of complexity. Legion. 2019.512 p.